

Performance Evaluation of Various Routing Protocols and quality of service for Wireless Sensor Network

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Abstract

Wireless sensor networks (WSNs) provide great promise for target tracking and environmental monitoring. While many WSN routing protocols have been proposed till date, most of these focus on the mobility of observers and assume that targets are fixed. But, practically, many applications require for sensing data to be propagated from multiple mobile targets to multiple mobile observers. In addition, WSNs often operate under strict energy constraints, and therefore reducing energy dissipation is also an important issue. Clustering in wireless sensor networks (WSNs) is an important technique to ease topology management and routing. Clustering provides an effective method for prolonging lifetime of a WSN. In this paper we discuss the performance of two protocols like Dynamic Source Routing (DSR), Dynamic MANET On-demand Protocol (DYMO) using CBR (Constant Bit Rate) and Traffic-Gen for Multi-Clustering technique and compare various parameters like Average End-to-End Delay (sec.), Residual Battery Capacity (mAh), No. of packets received at Coordinator, Average End-to-End Delay at PAN Coordinator (sec.) and Throughput at PAN Coordinator (bits/sec.)

Keywords: *Wireless sensor networks, Multi-clustering, Routing Protocols, Energy efficiency, Qualnet 5.0.2.*

INTRODUCTION

A wireless sensor network (WSN) is combination of many sensor nodes which are being deployed densely in the supervising region that communicates over radio waves. These networks are scalable and used in many practical applications like natural disaster recovery [1], large habitat monitoring and tracking of a target [2]. Due to the non-rechargeable and limited energy, the energy resource of sensor networks should be used in a smart way to extend the lifetime of network [3]. A sensor node is very small device which includes three basic components: a sensing

subsystem for data accomplishment from the surrounding physical environment, a processing subsystem for data processing and data storage, and a wireless communication subsystem for transmission of data and also a energy source that supplies the energy needed by the device for efficiently performing the assign task. This energy source mainly consists of a battery with a limited energy so it may be inconvenient or impossible to recharge the battery, because nodes may be deployed in an unfriendly or unpractical environment [4]. Now a day, unattended wireless sensor network (UWSN) has

become a subject of attention in the security research community of sensor networks [5-9]. In the unattended settings, a sensor is not able to communicate to sinks regularly in real time. Rather than it just collects data and waits for a signal to upload the accumulated data to mobile sinks. Fig. 1 illustrates the WSN architecture.

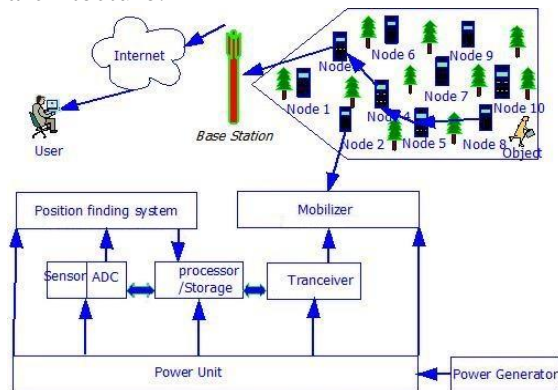


Fig 1 WSN Architecture

This lifetime may be order of several months, or may be years. So, the critical question is that how to extend the network lifetime for such a long time? There are two methods for enhancing the lifetime of the battery Clustering and Time scheduling. This paper investigates the clustering mechanism.

The standard IEEE 802.15.4 focuses on low-rate and low-power solutions for reliable wireless monitoring and control. It is specifically designed for discrete data sent occasionally [12]. In sensor network, there may be thousands of sensors that send a large amount of data simultaneously which should be tackling and treated efficiently. When the base station wants to get information, then it should have a real-time response. So the routing protocols play an important role in managing the formation, configuration, and maintenance of the topology of the network [13].

In recent years, WSN dissemination issue has been widely studied, with Faheem *et al.* presenting three patterns for

recognizing sink mobility [14]. One of these patterns: random mobility - is easily applicable to sink movements and is therefore the most commonly adopted [15, 16, 17, and 19]. However, random mobility requires continuous location updates, which results in higher levels of wireless transmission collisions and energy consumption [14].

Power management is an important issue in wireless sensor networks (WSNs) [18] because wireless sensor nodes are mainly powered by batteries, so the efficient use of the dischargeable battery power becomes an important aspect mainly for that type of applications where the whole system is required to operate for long period of time. This requirement for energy efficient operation of a WSN has motivated for the development of new protocols in all layers of the protocol stack. Through this paper we have discuss the performance of two protocols Dynamic MANET On-demand Protocol (DYMO) and Dynamic Source Routing (DSR) using CBR (Constant Bit Rate) and Traffic-Gen for clustering and have compare the various parameters like Throughput at PAN Coordinator (bits/sec.), No. of packets received at Coordinator, Residual Battery Capacity (mAh), Average End-to-End Delay at PAN Coordinator (sec.) and Average End-to-End Delay (sec.).

This paper contains many sections which is given below. In section 2 a brief overview of Ad-hoc Routing Protocols, Multi-Clustering and Traffic Generators is given. The related work is briefly described in section 3. In Section 4 the Network Simulation is discussed. Results of Simulations are presented in Section 5. At last, in section 6 we conclude the paper.

BRIEF OVERVIEW

Ad-hoc routing protocols

Ad-hoc routing protocols may be divided into 3 categories, Reactive (On demand)

routing protocol, Proactive (Table driven) routing protocol and Hybrid routing protocol. Fig. 2 shows classification of Ad-hoc routing protocols.

Proactive (Table-Driven) Routing Protocols

Proactive Routing Protocols [20] maintain information continuously. A node has a table that contains the information about the route to every other node and the algorithm that tries to keep the routing table up-to-date. If there are changes in network topology than those changes are propagated throughout the network.

Reactive (On-Demand) Routing Protocols

There are two different operations in on demand protocols [20] which are Route discovery and Route maintenance operation. In this protocol the routing information is gained on-demand. This is called as route discovery operation. If a route has been created then the changes in topology will be accrued, so the route maintenance is the process of responding to change in topology.

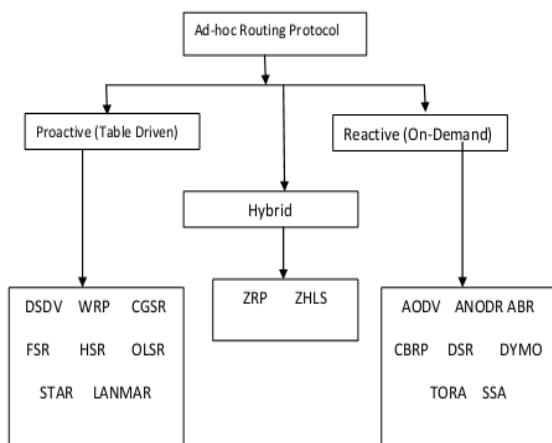


Fig. 2 Classification of Ad-hoc Routing Protocols

Hybrid Routing Protocols

Hybrid Routing Protocols are both Proactive and Reactive in nature. Most hybrid protocols which are proposed till

date are based on zone, which means that the network is considered as a number of zones by each node. Normally, Hybrid routing protocols for MANETs uses hierarchical network architectures.

Dynamic Source Routing (DSR)

The Dynamic Source Routing protocol (DSR) [21] is an efficient routing protocol which is designed to use in different multi-hop wireless ad hoc networks. All the network nodes collaborate to forward multiple packets for each other for allowing communication over a number of hops. As all the mobile nodes in the network may join or leave the network instantly. This type of routing is automatically determined and maintained by the DSR routing protocol. Since the number or the sequence of intermediate hops required reaching any destination may get change at any instant so the resulting network topology may be quite efficient and rapidly changing.

DYMO (Dynamic MANET On-demand Protocol)

On the other hand the Dynamic MANET On-Demand (DYMO) protocol [22] is very simple and fast routing protocol for multi-hop network. It finds unicast routes among DYMO routers within the network in on-demand manner, which offers improved convergence in dynamic topologies.

Multi-Clustering

Wireless Sensor Network (WSN), provides various computing platforms for the environmental monitoring and military field surveillance type of applications. The networks deployed in these applications are usually faced with an uneven environment in which it very typical and sometime impossible to recharge their node batteries. So it is necessary to make up specific protocol for these type of networks to enable its nodes to efficiently utilize their energy. A distributed network

some nodes are chosen to act as cluster heads (CHs) having certain probability, enables the self clustering of large numbers of nodes. These cluster heads contains the routing infrastructure and aggregate the data which they have gathered from their neighbouring non-cluster nodes. Among the cluster heads, the one which has more residual energy is picked out to be the coordinators [23]. The cluster heads need not to transfer information directly to the base station (PAN Coordinator) rather than it transfer it to Coordinators through which the information will be transferred to the base station.

Traffic Generators

A Traffic Generator models the traffic which behaves in a predefined structure and scheduled manner [25]. The following two traffic generators are used in the analysis:

1. Constant Bit Rate (CBR): CBR traffic Generator creates the payload which is fixed in size and packet interval. This UDP-based client-server application sends data from a client to a server at a CBR.
2. Traffic-Gen.: it is a random distribution-based traffic generator which is a flexible UDP traffic generator that supports a variety of data size and interval distributions. It also supports quality of service (QoS) parameters [26].

RELATED WORK

Samer A. B. Awwad *et al.* proposed CBR-Mobile protocols evaluated using MATLAB and compared to LEACH-Mobile and AODV protocols [27] and the evaluation parameters which are considered are given in Table 1. Megha Rastogi *et al.* focuses on routing protocols like AODV, DSR and DSDV and different traffic generators and their overall performance under different scenarios such as Packet Delivery Ratio and Throughput using NS2 (Network Simulator 2) version 2.35 [28] has been evaluated.

NETWORK SIMULATION

This Section enables us to analyze temporal assessment of Different routing protocol under the specified terrain conditions in wireless sensor networks.

Simulation Scenario

We have chosen Qualnet version 5.0.2 over Windows platform for our simulation studies. Qualnet is a discrete event simulator. It is equally capable of simulating various wired or wireless scenarios in simple as well as complex conditions. In the simulation model, there are 250 nodes and all of these are connected to one wireless station. The terrain condition we have set as 500m × 500m as flat area. The entire area is further divided into 100 square shaped cells. Simulation time we have used is 500s. All the nodes we have assumed as dynamic one. The type of wireless propagation model is Two Ray ground propagation. The numbers of constant bit rate (CBR) and TRAFFIC generator connection are 16. The entire connection set up has been done randomly. In this we use the concept of Reduced Functional Device (RFD) and Full Functional Device (FFD). Then we further make the Coordinator and PAN Coordinator. The Packet size reduces to 70 bytes because it only supports up to 128 bytes. Here different clusters are created and all nodes are divided among these clusters. We make Base station as PAN Coordinator and all cluster-heads as Coordinators. Table 2 gives all the parameters.

Simulation Scenario Parameters

1. Throughput: Throughput is the average rate of successful data packets received at destination. It is usually measured in bits per second (bit/s or bps), and sometimes in data packets per second.

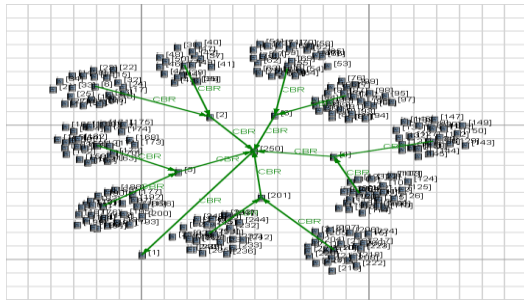


Fig. 3 Simulation Scenario with CBR

Table.1 simulation parameter

Parameter and models	Value
Network(Field) Size(L*W)	50 x 50 m
Number of sensor nodes(N)	100, 120,140
Location of the sink node	(25,25)
Sensor nodes deployment	Random deployment
Sensor ID	1-140
Maximum transmission range	19 m
Percentage of cluster head	5%
Percentage of mobile sensor nodes	0-90%
Data size	2000 bits
Mobility model	Random waypoint model with Speed(1-10) m/s
Radio model	Two-Ray Ground model
NEW_MEMBERSHIP_REQUESTERS database	Initially is empty
ALTERNATIVE_SCHEDULE	Reverse order of original schedule
Battery	Initial capacity is assumed to be constant
Traffic model	CBR traffic for periodic data generation
Queuing model	FIFO with Drop Tail Queue Mechanism

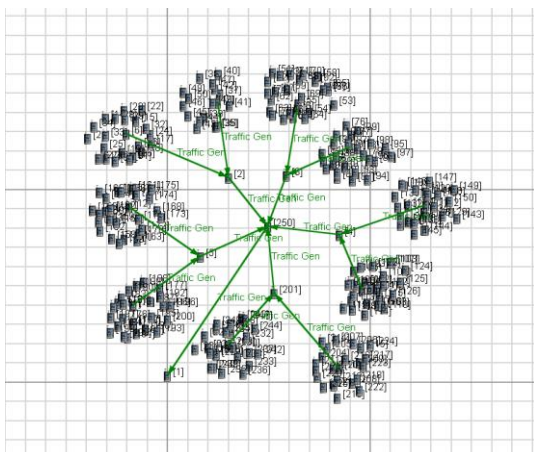


Fig 4- Simulation Scenario with Traffic Gen.

2. End-to-End Delay: End to end delays are measures as a specific packet is

transmitting from source to destination and then calculating the difference between send times and received times. The delay metric consists of delays due to route discovery, queuing, propagation and transfer time. We compare the parameters they used in their simulation from the Table 1 to Table 2 which is shown below:

SIMULATION RESULTS

In this research, we did the simulation of the performance analysis of Different routing protocols using the Qualnet 5.0.2 which is developed by Scalable Network Technology [29]. Qualnet 5.0.2 provides a comprehensive environment for designing protocols, creating and animating network scenarios, and analyzing their performance. On the basis of the above mentioned simulation scenario and parameters we have obtained the following results. The results are shown from Fig.5 to Fig.35.

Table 2- simulation parameters

PARAMETERS	CBR		TRAFFIC GENERATION	
	DSR	DYMO	DSR	DYMO
Area Size (Flat Area)	500m×500m	500m×500m	500m×500m	500m×500m
Attitude Above & Below Sea Level	1500m	1500m	1500m	1500m
Simulation Time	500 sec.	500 sec.	500 sec.	500 sec..
Wireless Propagation Model	Two Ray	Two Ray	Two Ray	Two Ray
Node Placement	Random	Random	Random	Random
Energy Model	MicaZ	MicaZ	MicaZ	MicaZ
Traffic Type	CBR	CBR	Traffic Gen.	Traffic Gen.
Data Source Distribution	100 square cells	100 square cells	100 square cells	100 square cells
Mobility Model	None	None	None	None
MAC Protocol	MAC80 2.15.4	MAC80 2.15.4	MAC80 2.15.4	MAC80 2.15.4

Network protocol	IPv4	IPv4	IPv4	IPv4
Routing protocol	DSR	DYMO	DSR	DYMO
No. of Nodes	250	250	250	250
Number of CBR	16	16	16	16
Mobility	None	None	None	None
No. of Channels	1	1	1	1
Channel Frequency	2.4GHz	2.4GHz	2.4GHz	2.4GHz
Packet Size (bytes)	70	70	70	70
Battery Model	Enabled	Enabled	Enabled	Enabled
Battery Charge Monitoring Interval	1 sec.	1 sec.	1 sec.	1 sec.
Full Battery Capacity (mAh)	50	50	50	50
PAN Coordinator (FFD)	1	1	1	1

Coordinator (FFD)	16	16	16	16
RFD's	233	233	233	233
Residual Battery Capacity (mAh)	49.895	49.866	49.901	49.893
No. of Packets Received at Coordinator	48	463	728	673
Average End-to-End Delay at PAN Coordinator (sec.)	10.7525	0.726633	0.963411	0.462878
Throughput at Pan Coordinator (bits/sec.)	38	54	48	60

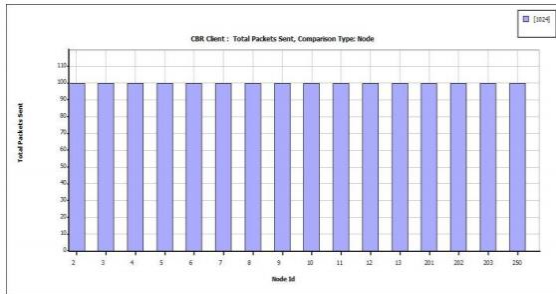


Fig 5 DSR input

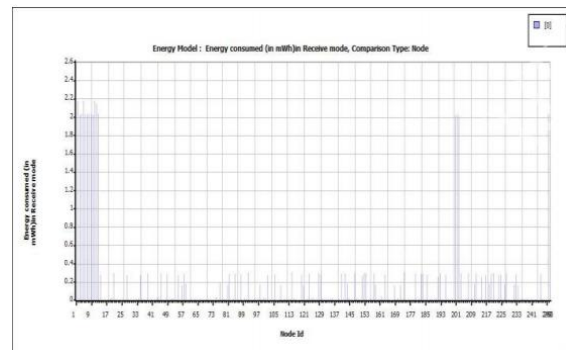


Fig 7 energy consumed in received mode(DSR)

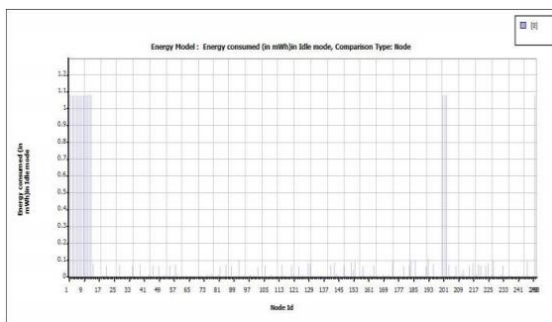


Fig 6 energy consumed in idle mode(DSR)

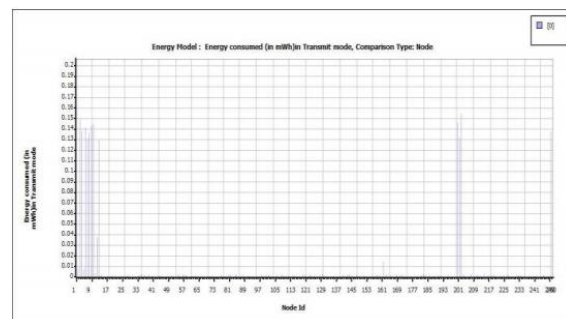


Fig 8 energy consumed in transmit mode(DSR)

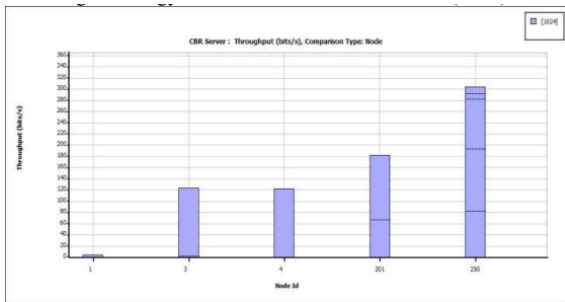


Fig 9 throughput at CBR server (DSR)

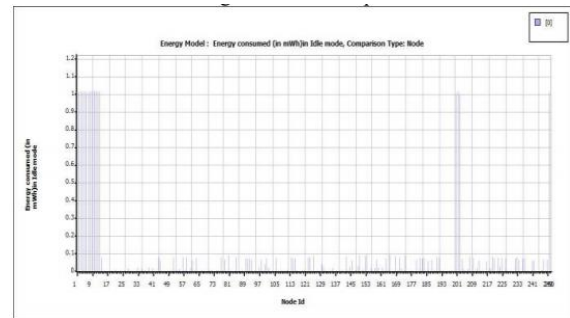


Fig 13 energy compused in IDLE mode (DYMO)

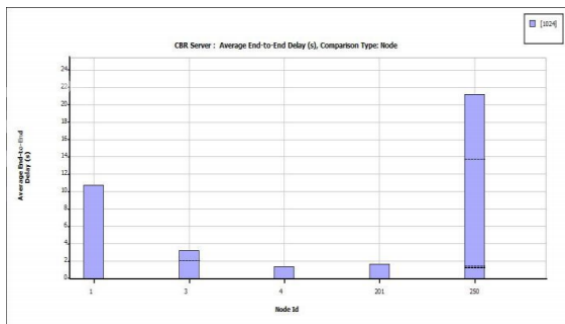


Fig 10 average end to end delay (DSR)

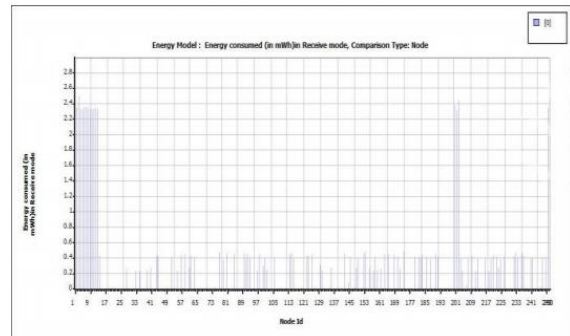


Fig 14 energy compused in received mode (DYMO)

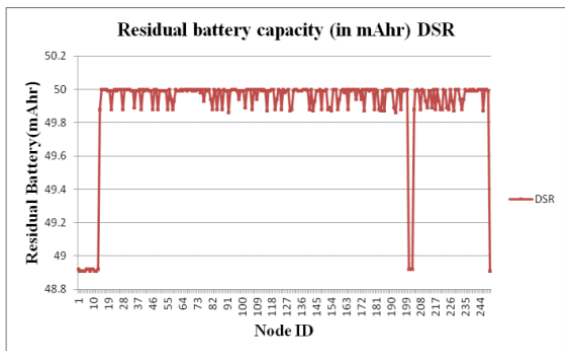


Fig 11 residual battery capacity(DSR)

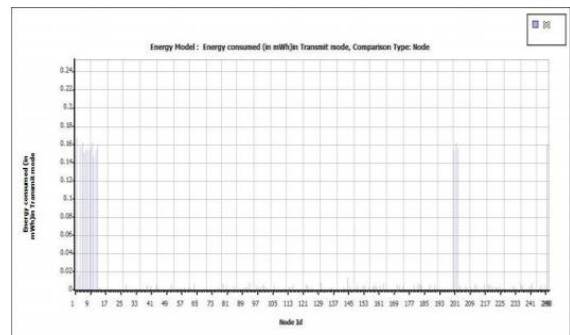


Fig 15 energy compused in transmit mode (DYMO)

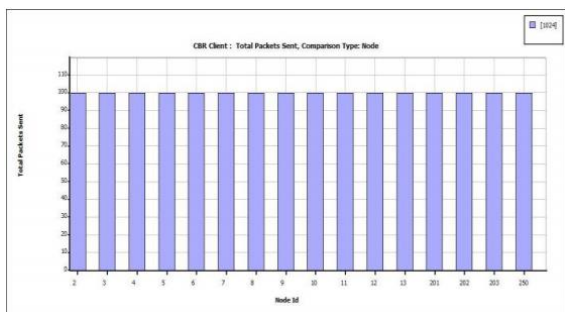


Fig 12 DYMO input

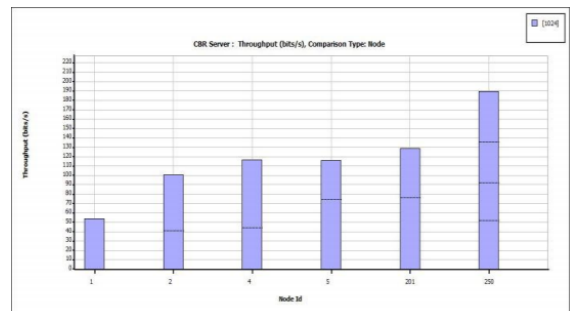


Fig 16 Throughput at CBR server (DYMO)

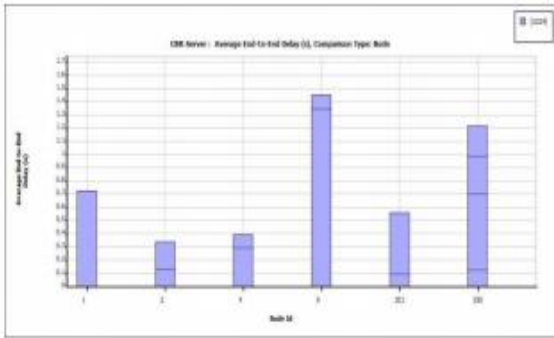


Fig 17 Average end to end delay (DYMO)

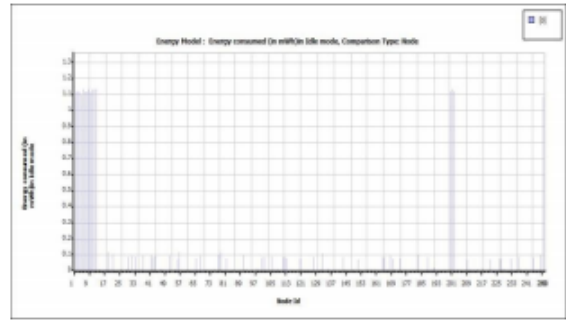


Fig 21 Energy Consumed in Idle Mode

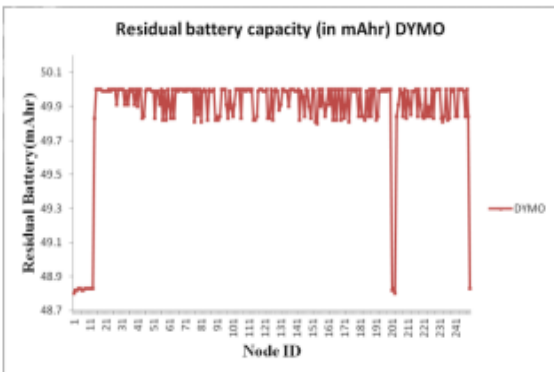


Fig 18 Residual Battery Capacity (DYMO)

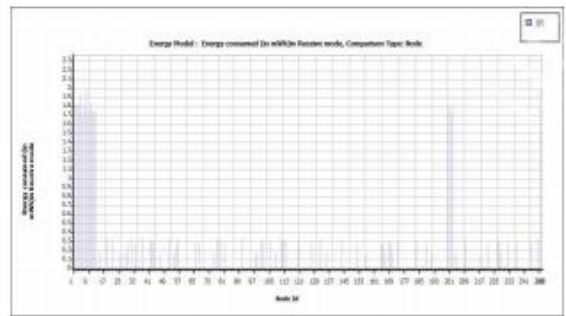


Fig 22 Energy Consumed in Recieve Mode

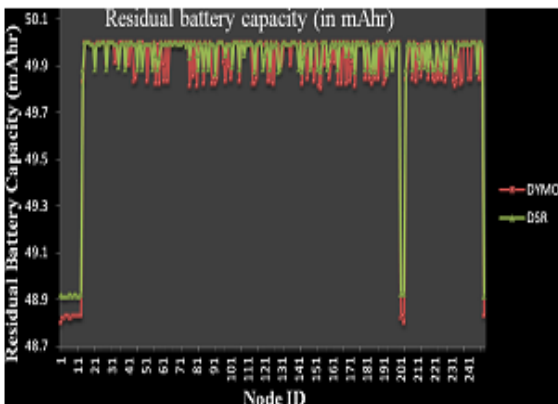


Fig 19 Comparison of DSR and DYMO at CBR server

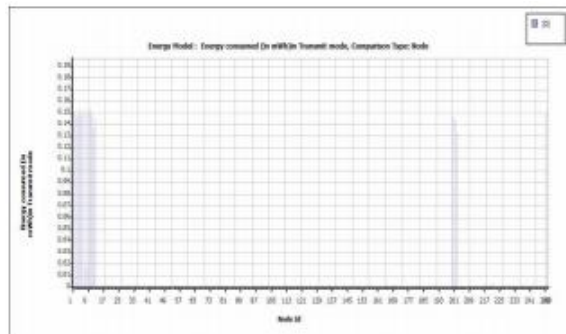


Fig 23 Energy Consumed in Transmit Mode

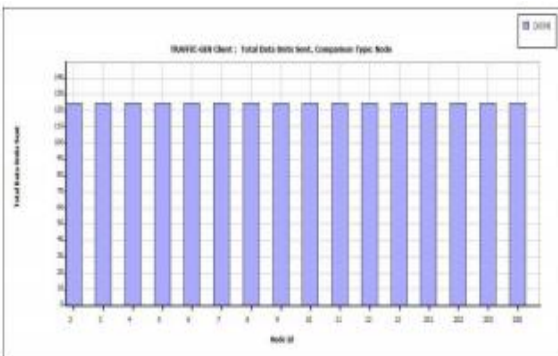


Fig 20 DSR Input

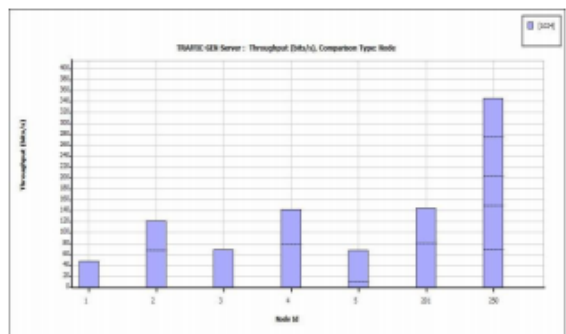


Fig 24 Throughput at CBR server

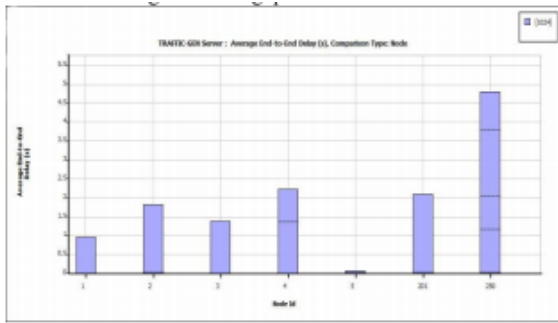


Fig 25 Average end to end Delay

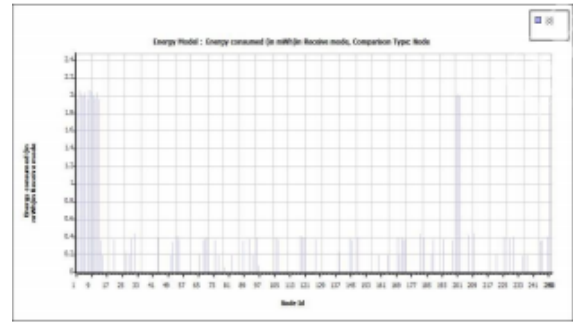


Fig 29 Energy Consumed in Receive Mode

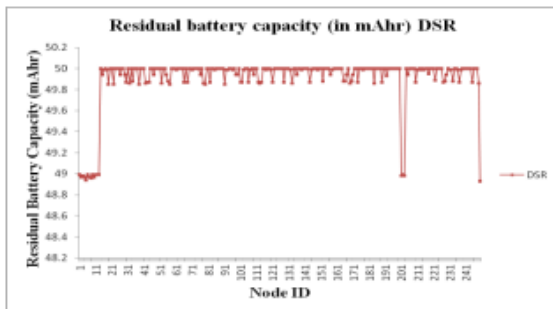


Fig 26 Residual Battery Capacity (DSR)

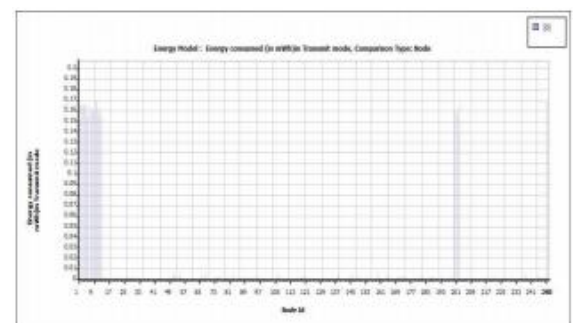


Fig 30 Energy Consumed in Transmit Mode

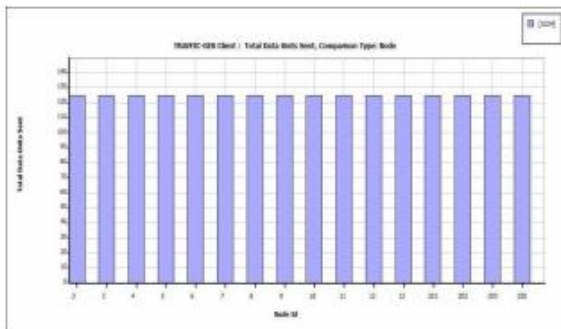


Fig 27 Dymo Input

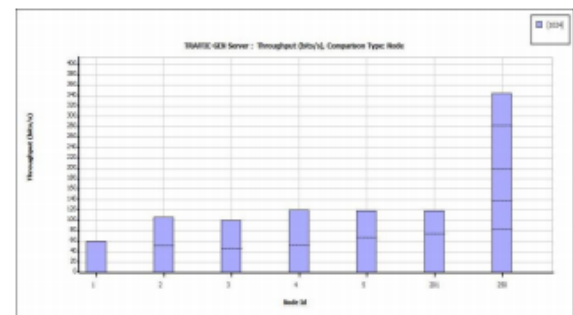


Fig 31 Through at CBR Server

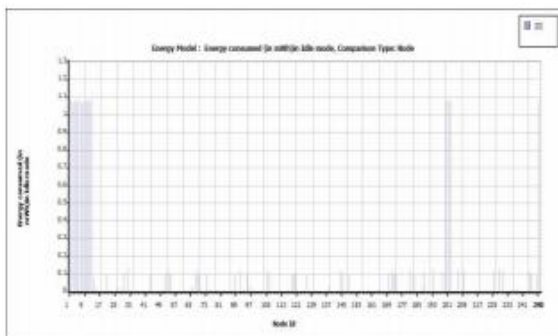


Fig 28 Energy Consumed in Idle Mode

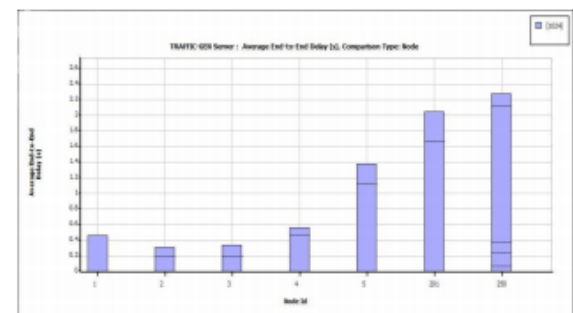


Fig 32 Average end to end Delay

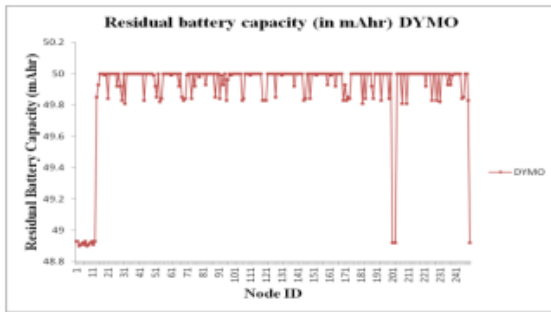


Fig 33 Residual Battery Capacity (DYMO)

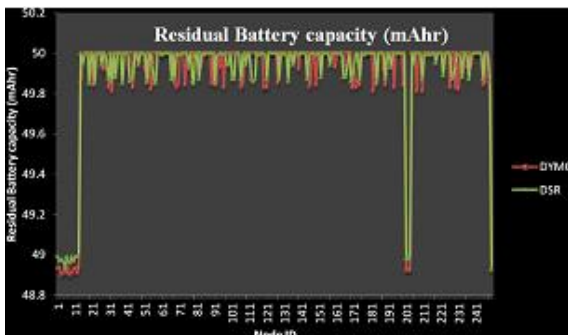


Fig 34 Comparison of DSR and DYMO at Traffic Generation



Fig 35 Comparison of Residual Battery of DSR and DYMO using and CBR and Traffic Generation

CONCLUSION

We have captured different figures for various protocols from Fig. 5 to Fig. 35 and compared the parameters like Residual Battery Capacity (mAhr), Average End-to-End Delay at PAN Coordinator (sec.) , No. of packets received at Coordinator and Throughput at PAN Coordinator (bits/sec.) for the DSR and DYMO routing Protocols using CBR and Traffic-Gen. From the Table 2, we conclude two facts in DYMO these are 1) No. of packets received at Coordinator and Throughput is higher, 2) Average end to end delay at PAN

Coordinator is less using CBR as well as Traffic-Gen. The Residual Battery Capacity is nearly same in both cases when simulated for the time period of 500s. By increasing the simulation time the better analysis of residual battery capacity can be achieved.

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